Considerations of the Use of SS3 ASPM-R as an Estimation Model in PBF MSE *

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Abstract

This document is a discussion paper that briefly reports simple comparisons of performance between full Stock Synthesis (SS3) and SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) when using these models as the estimation model (EM) in PBF management strategy evaluation (MSE). The use of SS3 ASPM-R and ASPM-R fitting to size composition data can reduce computation time (1/5 by ASPM-R fitting to size data and 1/20 by ASPM-R). Although trajectories of future TAC based on results from the EM of ASPM-Rs somewhat diverged from that of full SS3, TACs appeared to be determined according to the SSB trend. ASPM-R showed better performance than ASPM-R fitting to size in this regard. For the explorative purpose of testing candidate management procedures, the use of ASPM-R as a tentative EM merits to reduce computation time in the course of PBF MSE process.

1. Introduction

Upon a request from the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC), the International Scientific Committee for tuna and tuna-like species in the North Pacific Ocean (ISC) Pacific Bluefin Tuna Working Group (PBFWG) is in charge of developing a management procedure (MP) for PBF. Currently, the ISC-PBFWG has been setting up the management strategy evaluation (MSE) framework to test candidate MPs (Tommasi and Lee 2022). In the PBF MSE, the PBFWG plans to use the Stock Synthesis (SS3) software as the basis for the estimation model (EM). However, the EM based on SS3 requires a long computation time for MSE simulations even when applying parallel computing. Consequently, this poses time constraint and makes it difficult for conducting a large number of simulation runs to test candidate MPs under a wide array of uncertainty scenarios. As such, the PBFWG decided to consider the use of SS3 ASPM-R (Age-Structured Production Model with Recruitment deviations) as the EM alternative to the full use of SS3 (ISC-PBFWG 2022).

This document is a discussion paper that briefly reports simple comparisons of performance between SS3 ASPM-R and full SS3 when using these models as the EM in PBF MSE. Relevant consideration points for the future MSE work are also summarized.

2. Settings of MSE runs for this test

R function codes, input/data files, and SS3 (version 3.30.18) executable file currently available in the Github detommas/PBF_MSE repository were used. To use SS3 as ASPM-R for the EM, the relevant R function code, 'EM_fun_adj.R', was modified (added the ASPM-R switch). Related to this code modification, two control.ss files modified from 'control_simple_1719_2021.ss' (named "control_simple_1719_2021_ASPMR.ss" and "control_simple_1719_2021_ASPMR_size.ss") with negative phase values for all selectivity and time-varying selectivity were added to the 'PBF_MSE/Condition/1/SAM' directory: one for not to use size frequency information (set value=0 for like_comp=6), the other for to use size frequency information (left value=1 for like_comp=6). When the ASPM-R switch is on, it prompts the function to read either of the two

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control.ss files every time the EM function is called depending on choice of the option of w/ or w/o size frequency information.

The personal computer used for this performance test was Lenovo ThinkStation with a specifications: Intel(R) Core(TM) i9-9900 CPU @ 3.10GHz, 64.0 GB RAM, 64 bits Windows 11 Pro.

Same as in Tommasi and Lee (2022), the harvest control rule, HCR1a #15 (HCR15, Fig. 1), was used as an example. Settings for simulation runs (time horizon, assessment cycle, etc.) were all the same as in ones defined in the codes in the current PBF_MSE repository except for turning on the "do stock assessment" switch (set sa=1). We fixed simulation iteration to specific one (specific only 1 iteration) and ran the PBF MSE code using both full SS3 (w/ no selectivity deviation) and SS3 ASPM-R (w/ and w/o fitting to size composition data) as the EM, and compared the results.

Prior to this performance test, we ran the SS3 ASPM-R models using current data (for the short time base model) and checked whether the ASPM-R models gave reasonable assessment results. Run times were approximately < 3 min for ASPM-R fitting to size composition data and < 6 min for ASPM-R. The assessment result of ASPM-R fitting to size data was almost identical to that of the short time base model whereas ASPM-R was not able to give a similar result to the base model (Fig. 2). Although ASPM-R had this shortcoming, we considered it still had some merit to be utilized as the EM for the time-saving purpose in MSE, and thus decided to use it as well in the test.

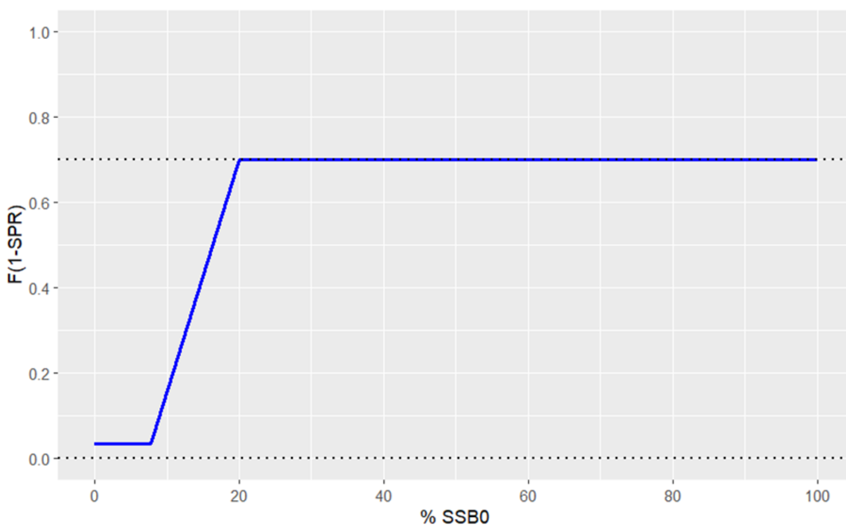

Fig. 1. Illustration of harvest control rule, HCR1a #15 (HCR15). HCR15 is characterized by: limit reference point = 7.7%$SSB_{F=0}$, threshold reference point = 20%$SSB_{F=0}$, target reference point = $F_{SPR30\%}$, minimum F = 5%F_{target}.

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Fig. 2. Results of stock assessments using SS3 ASPM-R (w/ and w/o fitting to size composition data) and current input data for the short time base model. The result of the short time base model is also shown for comparison.

3. Results

The results reported below were of the case of iteration #1 (set itr=1). We tried other iteration number cases (e.g., itr=5). Results from these other cases also had similar tendencies to the iteration #1 case.

Run times of MSE simulation were approximately 21.5 hr for full SS3, 1 hr for ASPM-R, and 5 hr for ASPM-R fitting to size composition. As expected beforehand, the use of either of the ASPM-Rs substantially saved run times (approximately 1/20 to 1/5 computation time reduction).

As the time step advanced in simulations, computation time in each time step tended to become longer, especially when using full SS3 or ASPM-R fitting to size composition (Fig. 3). This may be because the models need more time for parameter estimation in future time steps (maybe due to increase of data). We checked Report.sso files in the EM directory for each time step, and found some convergence problems for full SS3 and ASPM-R fitting to size composition in later time steps (i.e., final gradient values were considerably large for some later time steps and were yet reasonable for earlier time steps). There was not such problem observed for ASPM-R. This may explain why ASPM-R fitting to size composition took longer run time in MSE simulation than normal ASPM-R even though computation time of assessment using ASPM-R fitting to size composition was shorter (< 3 min) than ASPM-R (< 6 min).

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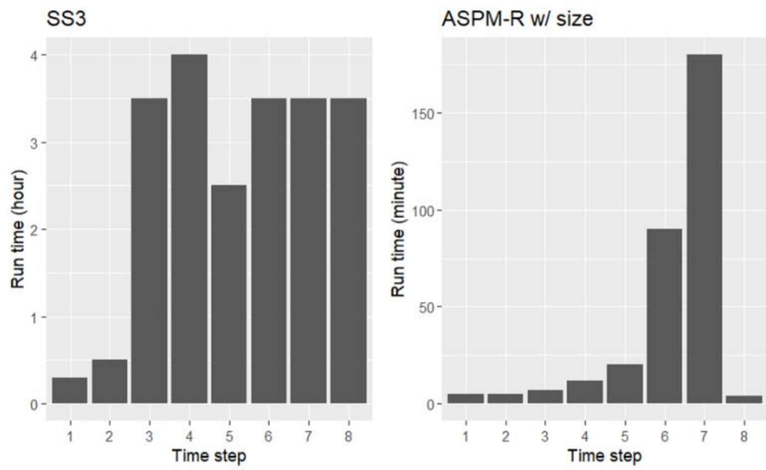

Fig. 3. Approximate computation time taken in each time step in MSE simulation (iteration #1 case, itr=1).

Trajectories of future TAC by using the three EMs became divergent as the time step of MSE simulation advanced (Fig. 4). A large decrease in TAC observed in the final time step for ASPM-R fitting to size data was caused by a convergence problem. Trajectories of future SSB also showed some differences among the three EMs. Although there was some divergence in increase/decrease patterns, overall trajectories of TAC determined by HCR15 based on results from full SS3 and two ASPM-Rs appeared to follow the trends of SSB.

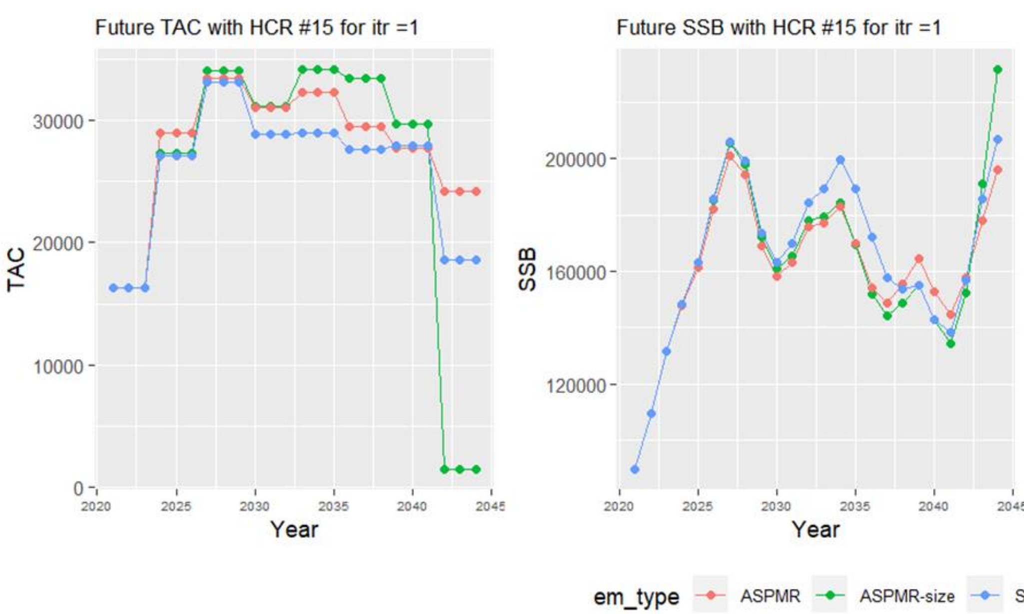

Fig. 4. Comparisons of future TAC and SSB trajectories resulted from MSE simulations (iteration #1 case, itr=1) using HCR15 and the three EMs (full SS3, ASPM-R w/ and w/o fitting to size composition data).

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4. Consideration points for future PBF MSE work

Based on the results above, we summarize consideration points for future PBF MSE work:

- The use of SS3 ASPM-Rs is able to reduce computation time (1/5 by ASPM-R fitting to size composition data and 1/20 by normal ASPM-R), which allows to conduct a larger number of simulation tests necessary for evaluating candidate MPs under a variety of scenarios in MSE.
- Although trajectories of future TAC based on results from the EM of ASPM-Rs somewhat diverged from that of full SS3, overall TACs appeared to be determined according to the SSB trend. Normal ASPM-R showed better performance than ASPM-R fitting to size composition data in this regard.
- Convergence problems about ASPM-R fitting to size composition data and also about full SS3 were observed in some later time steps of MSE simulation. There was no such problem about normal ASPM-R. These problems should be considered/resolved for future MSE if needed.
- The use of normal ASPM-R as a tentative EM merits to reduce computation time without convergence issue in the course of MSE process. For example, in exploring phase of MSE process, ASPM-R is used as a tentative EM and a large number of simulation runs can be done to test candidate MPs. Then, in final evaluation/selection phase, definitive MSE is implemented by switching the tentative EM to full SS3.

References

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